

Management Plan for the

BROAD BEECH FERN

(*Phegopteris hexagonoptera*)

in Ontario



About the Ontario Management Plan Series

This series presents the collection of management plans that are written for the Province of Ontario and contain possible approaches to manage species of special concern in Ontario. The Province ensures the preparation of the management plans meet its commitments to manage species of special concern under the *Endangered Species Act, 2007* (ESA, 2007) and the Accord for the Protection of Species at Risk in Canada.

What is a species of special concern?

A species is classified as special concern if it lives in the wild in Ontario, is not endangered or threatened, but may become threatened or endangered due to a combination of biological characteristics and identified threats.

What is a management plan?

Under the *ESA, 2007*, a management plan identifies actions that could be taken to ensure, at a minimum, that a species of special concern does not become threatened or endangered. The plan provides detailed information about the current species population and distribution, their habitat requirements and areas of vulnerability. The plan also identifies threats to the species and sets a clear goal, possible strategies, and prioritized activities needed to address the threats.

Management plans are required to be prepared for species of special concern no later than five years of the species being added to the Species at Risk in Ontario list as a special concern species.

What's next?

Nine months after the completion of a management plan a government response statement will be published which summarizes the actions that the Government of Ontario intends to take in response to the plan and the government priorities in taking those actions. The implementation of the management plan depends on the continued cooperation and actions of various sectors, government agencies, communities, conservation organisations, land owners, and individuals.

For more information

To learn more about species of special concern in Ontario, please visit the Ministry of Natural Resources Species at Risk webpage at:
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DECLARATION

The management plan for the Broad Beech Fern was developed in accordance with the requirements of the *Endangered Species Act, 2007* (ESA). This management plan has been prepared for the Government of Ontario, other responsible jurisdictions and for the many different constituencies that may be involved in managing the species.

The management plan does not necessarily represent the views of all of the individuals who contributed to its preparation, or the official positions of the organizations with which the individuals are associated.

The goals, objectives and management approaches identified in the plan are based on the best available knowledge and are subject to revision as new information becomes available. Implementation of this plan is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

Success in the management of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan.

RESPONSIBLE JURISDICTIONS

Ontario Ministry of Natural Resources
Environment Canada - Canadian Wildlife Service, Ontario

EXECUTIVE SUMMARY

Broad Beech Fern (*Phegopteris hexagonoptera*) is a perennial fern with broadly triangular fronds that grow from 25 to 75 cm tall. It occurs only in North America, and is at its northern limit in southern Quebec and Maine, occurring as far west as southeastern Minnesota, and south to Texas and Florida. Because of population declines associated with habitat loss and deterioration, Broad Beech Fern was designated as special concern nationally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1983, and provincially in Ontario in 1990. In Canada, scattered populations have been documented from southwestern Ontario, eastern Ontario, and southern Quebec. Of the 71 known occurrences in Ontario, only 21 have been reported in the past 20 years. The lack of recent observations may be an indication of decline.

Broad Beech Fern prefers rich, undisturbed deciduous forest, particularly mature Beech-maple (*Fagus grandifolia* - *Acer* spp.) forests. Although it can be found in fresh to dry-fresh deciduous forests, Broad Beech Fern typically occurs in moister situations such as lower valley slopes, bottomlands and even swamps. It can be found in sunnier locations in mature forests, possibly having adapted to grow in canopy gaps in older growth forest. It is nonetheless primarily a shade-tolerant species and is unlikely to withstand major opening of the forest canopy.

Characteristics contributing to the vulnerability of Broad Beech Fern include the:

- inability of the species to withstand habitat alteration;
- isolation of many of the extant populations and the lack of suitable habitat between populations to allow for genetic exchange, dispersal and population expansion; and
- moist habitat required for sexual reproduction via spores, which could be impacted by increased droughts caused by climate change.

Habitat loss and degradation are considered the most significant threats to Broad Beech Fern in Ontario. Southern Ontario, and particularly the “Carolinian life zone” (Ecoregion 7E) of southwestern Ontario, where the majority of Ontario’s Broad Beech Fern populations occur, is one of the most highly impacted landscapes in Canada. This region has seen great reductions in forest cover, high levels of habitat fragmentation and increased human use within the remaining forest habitat. This is particularly important as Broad Beech Fern is sensitive to direct physical impact and disturbance to the forest canopy and does not do well in younger second growth forest conditions.

Although Broad Beech Fern does occur in some protected areas in Ontario, most populations are on private land and may be threatened by forest management and other human activities. These other threats include:

- trampling of plants and soil compaction caused by trail use (by pedestrians, cyclists, equestrians, all-terrain vehicle users and domestic pets) that pass through or near Broad Beech Fern populations;
- gardening and landscaping activities close to forest habitat;

- competition from invasive species;
- changes in soil chemistry caused by exotic earthworms;
- changes in hydrology associated with tile drainage and subdivision development;
- impacts on habitat from overabundant populations of White-tailed Deer;
- changes in forest habitat processes, composition and structure caused by virulent tree diseases and insect pests; and
- the potential collection of Broad Beech Fern for native plant gardens and other ornamental purposes.

This management plan offers strategies to maintain or enhance the population of Broad Beech Fern in Ontario to viable levels. The objectives of this management plan are:

1. Identify, protect and manage extant populations of Broad Beech Fern and habitat in Ontario.
2. Address key knowledge gaps relating to minimum viable population size, life cycle requirements, habitat requirements, and prioritization of threats.
3. Support and implement landscape- and ecosystem-based planning and recovery initiatives to increase the amount of available habitat for Broad Beech Fern, and enhance habitat connectivity for dispersal and population expansion.
4. Promote awareness and stewardship of Broad Beech Fern with First Nations and with stakeholders such as land managers, private landowners, municipalities and others.
5. Reassess conservation status of Broad Beech Fern in Ontario.

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1.0 SPECIES ASSESSMENT AND CLASSIFICATION

COMMON NAME (population): Broad Beech Fern

SCIENTIFIC NAME: *Phegopteris hexagonoptera* (Michx.) Fée

SARO List Classification: Special Concern

SARO List History: Special Concern (2004)

COSEWIC Assessment History: Special Concern (1983)

SARA Schedule 1: N/A (SARA Schedule 3: Special Concern)

CONSERVATION STATUS RANKINGS:

GRANK: G5

NRANK: N3

SRANK: S3

The glossary provides definitions for the abbreviations above.

2.0 SPECIES INFORMATION

2.1 Species Description and Biology

Species Description

Broad Beech Fern (*Phegopteris hexagonoptera*), is a perennial fern with broadly triangular, pinnate-pinnatifid fronds that grow from 25 to 75 cm tall (Smith and Rothfels 2004). The frond blades are between 15 and 30 cm wide, and about as long as wide (Vincent 1981, Smith and Rothfels 2004). The fronds grow closely spaced along a long-creeping underground stem (rhizome) that is slender, scaly and slightly fleshy (Vincent 1981, Smith and Rothfels 2004). Broad Beech Fern has a winged rachis (main axis), which is the primary difference between it and other fern species in Canada.

The scientific name of Broad Beech Fern has changed over time and *Dryopteris hexagonoptera* and *Thelypteris hexagonoptera* are still used in some of the literature. The common name Southern Beech Fern is also occasionally used.

The beech fern genus (*Phegopteris*) contains three species: Broad Beech Fern, Northern Beech Fern (*Phegopteris connectilis*) and Japanese Beech Fern (*Phegopteris decursive-pinnata*), which is not native to North America. Broad Beech Fern is similar in appearance to the Northern Beech Fern (*Phegopteris connectilis*), which is widespread in Ontario. Table 1 displays the key differences between the two Ontario species according to Smith and Rothfels (2004).

Table 1. Characteristics distinguishing Broad Beech Fern from Northern Beech Fern.

Broad Beech Fern	Northern Beech Fern
Midrib winged between all pinnae	Midrib free between first and second pinnae
Lowest pinnae broadest in the middle	Lowest pinnae tapering
Lowest pinnae spreading to ascending	Lowest pinnae projecting downwards
Pinnules on the lowest pinnae often lobed	Pinnules entire or at most with wavy margins
Frond as wide or wider than long	Frond longer than wide

Detailed technical descriptions and identification keys can be found in Cobb (1963) and Cody and Britton (1989).

Species Biology

Broad Beech Fern is a perennial species that reproduces both asexually and sexually. Asexual reproduction occurs via branching of the rhizome. New shoots emerge from this rhizome, which explains why Broad Beech Fern is often found in large dense patches or colonies (Vincent 1981, Smith and Rothfels 2004). Frond densities ranging from 1 to 120 per square metre have been measured in such patches, although no attempt was made to distinguish between sexual and asexual growth in these estimates (Smith and Rothfels 2004). A plant at Pinehurst Lake Conservation Area took four years before showing signs of vegetative growth, increasing from one to four fronds via rhizomes in that period (Jolly pers. comm 2012).

Broad Beech Fern reproduces sexually via dispersal of tiny spores, which appear in late summer or fall. These spores form on the undersides of fertile fronds and can be transmitted by wind over great distances (Vincent 1981, Smith and Rothfels 2004). If the spores land in a suitably moist environment, a gametophyte will form. A gametophyte is a small (1 cm) plantlet that contains half of the genetic information required to form a fern plant. The gametophyte has two sets of reproductive parts, both male and female, and fertilization is required to transform this plantlet into an actual fern. A film of moisture must be covering the gametophyte in order for fertilization to occur. The sperm cells swim to the eggs cells and the fertilized cells fuse, creating a cell with a full set of genes for an independent Broad Beech Fern plant (Encyclopaedia Britannica, 2013).

Some older literature suggests that Broad Beech Fern has hybridized with Northern Beech Fern (Mulligan et al. 1972, Vincent 1981). However, a recent study based on genetics and morphology of plants in northeastern North America found no evidence of this (Driscoll et al. 2003).

Broad Beech Fern appears to be tolerant of some sunlight and can be found in sunnier locations in mature forests (Maine Department of Conservation 2004), possibly having

adapted to grow in canopy gaps in older growth forest (Maine Department of Conservation 2004). It is nonetheless primarily a shade-tolerant species and is unlikely to withstand major opening of the forest canopy (Oldham 2004, Smith and Rothfels 2004).

Many species associated with Broad Beech Fern habitat in Ontario have southern affinities, indirectly suggesting that the range of Broad Beech Fern is limited by climatic conditions (Smith and Rothfels 2004). However, occurrences in Muskoka and Bruce County as well as Quebec are not entirely consistent with this hypothesis.

2.2 Population and Distribution

Broad Beech Fern occurs only in North America, and is at its northern limit in southern Quebec and Maine, occurring as far west as southeastern Minnesota, and south to Texas and Florida. It is of conservation concern (ranked S3 or higher) in six states and in the two Canadian provinces in which it occurs (Table 2), all of them at or near the northern limits of its distribution (NatureServe 2012). It is known only historically from Kansas. The Canadian distribution of Broad Beech Fern is limited to the Mixedwood Plains ecozone and southern edge of the Boreal Shield ecozone. Scattered populations have been documented at sites in southwestern Ontario, eastern Ontario, and southern Quebec (Oldham 2004).

Table 2. Conservation status of Broad Beech Fern by state and province.

S Rank	State / Province
SH	Kansas
S1	
S2	Maine, Minnesota, Rhode Island, Vermont, Wisconsin
S3	Ontario, Quebec, Iowa
S3 S4	Illinois
S4	Delaware, New Jersey
S4 S5	New York
S5	District of Columbia, Kentucky, North Carolina, Virginia, West Virginia
SNR	Alabama, Arkansas, Connecticut, Florida, Georgia, Indiana, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Hampshire, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas

(NatureServe 2012)

Ontario's Natural Heritage Information Centre (NHIC) has element occurrence (EO) records for Broad Beech Fern dating back to 1889. Unfortunately these historical records do not adequately describe the current distribution of Broad Beech Fern (NHIC 2013). Based on NHIC (2013), Smith and Rothfels (2004) and more recent reports (e.g., Jolly pers. comm 2012, Slavik pers. comm. 2013, Garofalo pers. comm. 2013)

only 21 of the 71 element occurrences for the species in Ontario have been reported in the past 20 years (Table 3). Oldham (2004) noted in 2004 that 46% of the element occurrences were ranked as historic or extirpated, and that while it was possible that the species still exists at some of the sites where it is considered historic, it has been found very infrequently in more recent surveys.

For example, Riley et al. (1996) surveyed 107 natural areas in the Niagara Escarpment Biosphere Reserve and found Broad Beech Fern at only four sites and were unable to find it at an additional four historic survey sites. Similarly, Ambrose and Waldron (Ambrose pers. comm. 2004 in Oldham 2004) conducted botanical inventories in 24 upland forests in Norfolk County and did not find Broad Beech Fern at any of the survey sites (Oldham 2004). In 2002, Rothfels visited nine known Broad Beech Fern sites and found the species at only three of them (Smith and Rothfels 2004). In 2004, Broad Beech Fern was found at only 6 of 19 known element occurrences during targeted surveys (NHIC 2006). Oldham (2004) notes that Broad Beech Fern is a relatively-conspicuous and recognizable species, and is thus unlikely to be overlooked in botanical surveys. This suggests ongoing decline in the province. The possible disappearance in recent decades of such a large proportion of occurrences is of considerable concern, and points to the need for additional surveys as well as a reassessment of the conservation status of Broad Beech Fern in Ontario.

From element occurrence records it is difficult to determine abundance. There are inconsistencies in how abundance has been recorded. Some observers record “fronds” others record “sites”. Other words used to describe individual populations in Ontario by different observers include “lones,” “patches,” “individual fronds,” “local,” “stand,” “extant” and “are” (NHIC 2013). This makes it difficult to make statements regarding population health and trends, even where extant populations have been re-examined over the years. Smith and Rothfels (2004) reported that only nine Ontario sites had been documented since 1995, with the largest of these, at Rondeau Provincial Park, having an estimated 14,000 fronds in five patches. Detailed population counts of this occurrence appear not to have been made since then, but it is described as “healthy” (Woodliffe pers. comm. 2013) and largely inaccessible to the public (Slavik pers. comm. 2013).

The map in Figure 1 illustrates the current and historic distribution of Broad Beech Fern in Ontario. Historic occurrences are locations where the species has not been observed in at least 20 years but may still persist.

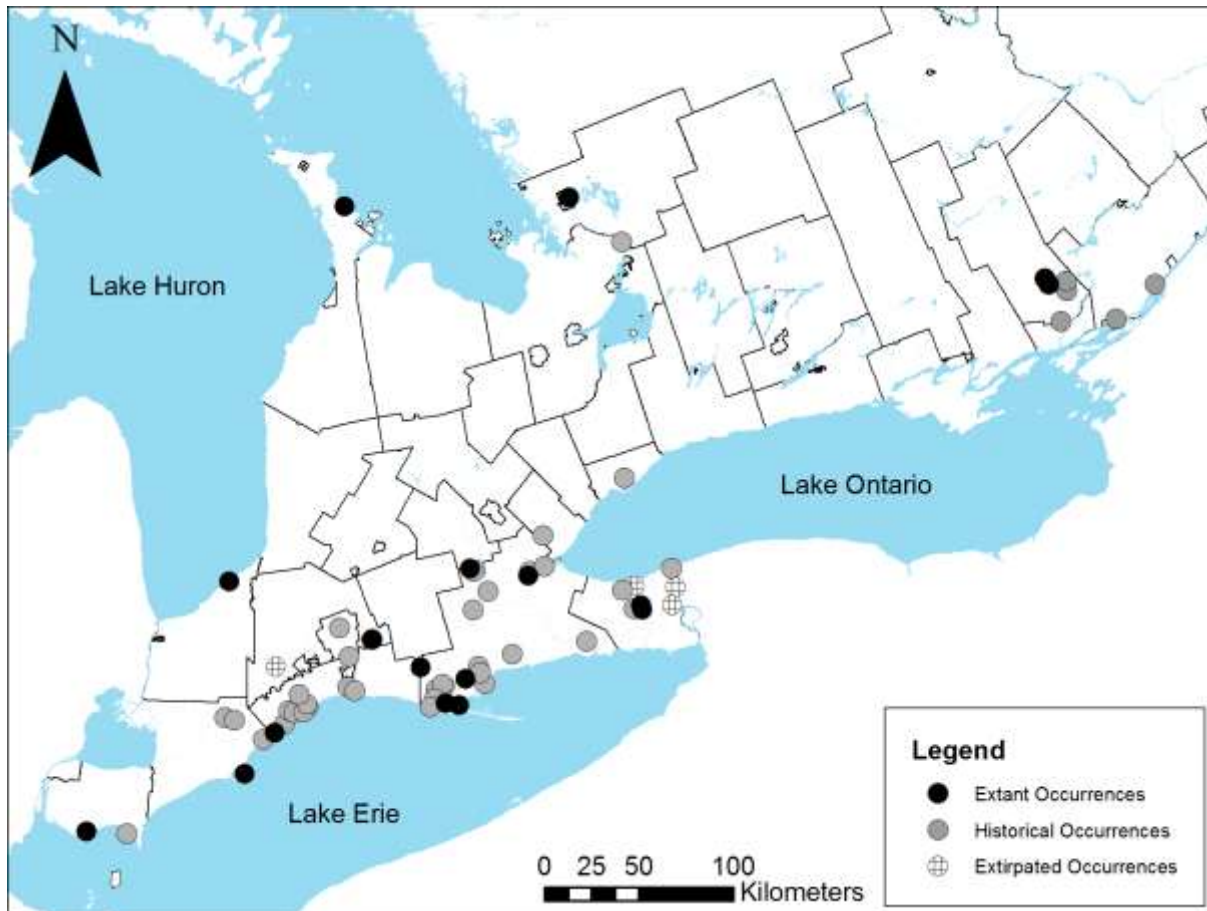


Figure 1. Historical and current distribution of Broad Beech Fern in Ontario.

2.3 Habitat Requirements

Broad Beech Fern prefers rich, undisturbed mature deciduous forest, particularly mature Beech (*Fagus grandifolia*) – maple (*Acer* sp.) forests (Vincent 1981, Dickson and White 1983, Maine Department of Conservation 2004, Smith and Rothfels 2004). Although it can be found in fresh to dry-fresh deciduous forests, it typically occurs in moister situations such as lower valley slopes, bottomlands and even swamps. Habitat descriptions for occurrences in Ontario, although often brief and cryptic, include terms like: —mist rich valley, mature hardwood forest,” “moist woods,” “swamp,” “edge of...swamp,” “edge of small...woodland stream,” “rich moist deciduous bottomlands,” —wet mesic valley,” —stream floodplain” and —slough forest” (NHIC 2013). The descriptor —sandy” was used in six element occurrence records to describe the soil type of the habitat. —clay” and —sandy loam” were mentioned twice. A correlation with nitrogen-rich soils has been cited (Doroski 2009). Low nitrogen content in the soil could be a limiting factor for this species.

While mainly associated with Maple (*Acer* spp., often *Acer saccharum*) - Beech forest, other species have been observed including: (4) White Ash (*Fraxinus americana*), (3) Basswood (*Tilia americana*), Hemlock (*Tsuga canadensis*), Yellow Birch (*Betula*

allegheniensis), hickory (*Carya* spp.), oak (*Quercus* spp.), (2) Tulip Tree (*Liriodendron tulipifera*), Ironwood (*Ostrya virginiana*), Black Ash (*Fraxinus nigra*), Butternut (*Juglans cinerea*), Sassafras (*Sassafras albidinum*), elm (*Ulmus* spp.), Blue Beech (*Carpinus caroliniana*); (4) Maidenhair Fern (*Adiantum pedatum*), (2) Spicebush (*Lindera benzoin*), May-apple (*Podophyllum peltatum*), and various ferns (NHIC 2013).

2.4 Characteristics Contributing to Vulnerability of Species

Characteristics contributing to the vulnerability of Broad Beech Fern include:

- the inability of the species to withstand habitat alteration;
- the isolation of many of the extant populations and the lack of suitable habitat between populations to allow for genetic exchange, dispersal and population expansion; and
- the suitably-moist habitat required for gametophyte generation, which could be impacted by increased frequency of droughts resulting from climate change.

3.0 THREATS

Natural ecosystems are continually evolving in response to a variety of forces and factors. But they are limited in their ability to adapt to rapid change, such as that introduced through human activities. Humans sometimes disrupt and degrade biodiversity through habitat loss, introduction of invasive species, population growth, pollution, unsustainable use and climate change. Our growing population combined with our rising levels of resource consumption can threaten biodiversity (OBC, 2011). Recently, an assessment of pressures on Ontario's biodiversity showed that many threats are increasing (OBC, 2010b).

The following threats have been identified as impacting Broad Beech Fern:

Habitat Loss

Habitat loss and degradation are considered the most significant threats to Broad Beech Fern in southern Ontario (Vincent 1981, Oldham 2004, Smith and Rothfels 2004) and particularly the —Carolinia life zone” (Ecoregion 7E) of southwestern Ontario. This region, where the majority of Ontario's Broad Beech Fern populations occur, is one of the most highly impacted landscapes in Canada. It has seen great reductions in forest cover, high levels of habitat fragmentation, and high levels of human use within the remaining forest habitat (Jalava et al. 2009). Broad Beech Fern is sensitive to direct physical impact, to microclimatic variation caused by disturbance to the forest canopy, and does not do well in younger second growth forest conditions (Argus and Pryer 1990).

Although Broad Beech Fern does occur in some protected areas in Ontario, the majority of populations (>50%) are on private land and could be threatened by forest management and other human activities (Oldham 2004). Smith and Rothfels (2004) note that in Ontario the fern has only been found in undisturbed or little-disturbed mature forests. No evidence has been found to suggest that silviculturally appropriate forest management practices have a negative effect on Broad Beech Fern. However, logging that significantly opens the canopy (thereby increasing sunlight, ground-level temperatures, and daily temperature fluctuations) may stress a plant species with relatively high shade and moisture requirements. Forestry operations may also cause soil compaction and erosion, understory damage, hydrological changes and introduce invasive species, as noted in recovery strategies for other species at risk that occupy the same or similar woodland habitats (e.g. Jalava and Ambrose 2012a, 2012b). The fact that Broad Beech Fern can be found in —sunny, more open locations within moist woods,” according to the Maine Department of Conservation (2004) would suggest, that careful selective logging (the practice of removing one or two trees from a forest stand while leaving the rest intact) or selection cutting (a silviculture practice of harvesting trees to move a stand toward an uneven-aged stand) (OMNR 2011) might not always be harmful.

Extensive forest disturbance due to removal of ash trees to control Emerald Ash Borer may have impacted (and may continue to impact) Broad Beech Fern populations in Ontario due to canopy opening and mechanical disturbance to the understory during these operations (Oldham 2004). Fragmentation of woodlands is another concern since this species tends to be found in large woodland tracts (Oldham 2004).

Habitat alterations such as impacts from deer include browsing, trampling and soil compaction, which change overall forest structure and understory composition (Gould pers. comm. 2013, Brdar pers. comm. 2013, OMNR 1991, Tanentzap et al. 2010b). Habitat alteration by deer is a concern at one Broad Beech Fern occurrence and possibly others. Deer browse on understory vegetation, including small trees and seedlings on the forest floor and can cause declines in understory tree regeneration. This, along with the death of older trees in the long-term, can lead to gaps in the canopy and changing light levels in the forest (Tanentzap et al. 2010b). Tanentzap et al. (2010b) suggest that the reduction of small trees caused by the overabundance of deer can cause continued decline in canopy cover, even after browsing pressures have abated.

Other associated impacts of population growth and intensification of land uses in southern Ontario may include:

- trampling of plants and soil compaction caused by increased use of both formal and informal trails (by pedestrians, cyclists, equestrians, all-terrain vehicle users and domestic pets) that pass through or near Broad Beech Fern populations;
- encroachment of adjacent gardening and landscaping activities into forest habitat, particularly for Broad Beech Fern populations found in suburban or other higher population density areas;
- introduction of invasive species (resulting from both trail use and encroachment); and
- changes in hydrology associated with tile drainage and subdivision development (resulting in reduced soil moisture required by the species).

Invasive Species

Ontario's Invasive Species Strategic Plan defines invasive species as —~~harmful~~ alien species whose introduction or spread threatens the environment, the economy, or society, including human health.” (OMNR 2012). Invasive species may also include species native to Ontario that have expanded their range due to human activity and are damaging the new ecosystem (OMNR 2012). Invasive species are of particular concern in areas where high human population densities, strong import-export markets and degraded habitat have made the landscape vulnerable to the establishment of new species (OMNR 2012).

Invasive exotic plant species such as Garlic Mustard (*Alliaria petiolata*) are increasingly abundant in southern Ontario (Oldham 2004). It has been found near Broad Beech Fern at Backus Woods (Smith and Rothfels 2003) and undoubtedly elsewhere. Garlic Mustard is highly invasive, quickly outcompeting native species for light, water and nutrients (Yates and Murphy 2007, Rodgers et al. 2008). It has many characteristics

that make it quick to establish and compete: phenotypic plasticity (Dukes et al. 2008), high seed production and the plant contains a toxin that makes it unpalatable to many native herbivores (Yates and Murphy 2007). Other aggressive invasive species of concern in Carolinian forests of Ontario include Periwinkle (*Vinca minor*) (Smith and Rothfels 2004), Dame's Rocket (*Hesperis matronalis*) and Dog-strangling Vine (*Vincetoxicum* spp.) (Fletcher et al. 2013, Draft). The introduced shrub Japanese Barberry (*Berberis thunbergii*) is another common invasive species in the Beech-maple forests of southwestern Ontario (Gould, pers. comm. 2013). The degree to which such exotic species have invaded or impacted Broad Beech Fern sites is not well documented. Given their widespread distribution in southern Ontario, they are quite possibly a significant threat to the species. However, no invasive species are cited in element occurrence records for the species (NHIC 2013).

Exotic earthworms are also having an impact on the deciduous forests of eastern North America (Evers et al. 2012, Sackett et al. 2012). Earthworms are ecosystem engineers that strongly influence soil structure and nutrient cycling (Bohlen et al. 2004ab, Frelich et al. 2006, Sackett et al. 2012, Tanentzap et al. 2010a). Of the 19 species of earthworm found in Ontario today, not one is native to the province. Forests in Ontario have evolved without the influence earthworms (Evers et al. 2012). Evers et al. (2012) suggests that introduction and establishment of earthworms —old significantly alter forest structure, chemistry, and biodiversity, including understory vegetation, soil fauna, and below ground fungal communities.” Gould (pers. comm. 2013) and Woodliffe (pers. comm. 2013) suggest that earthworms may be a threat to Broad Beech Fern habitat. Among the many effects exotic earthworms have on an ecosystem, increased loss of soil nitrogen through leaching (Hendrix and Bohlen 2002) could be a threat to Broad Beech Fern if the affinity with nitrogen-rich soils made by Doroski (2009) is valid. Furthermore, earthworms may impact the regeneration of native herbaceous and woody species by affecting fungal processes (Woodliffe, pers. comm. 2013).

Disease

Broad Beech Fern habitat may be significantly affected by tree diseases and pests. Beech bark disease, Emerald Ash Borer (*Agilus planipennis*), Asian Long-Horned Beetle (*Anoplophora glabripennis*) and Gypsy Moth (*Lymantria dispar*) are impacting or have the potential to impact the deciduous forest of southern Ontario and Broad Beech Fern habitat. Introduced to Canada in the 1890s, Beech bark disease is caused by a scale insect (*Cryptococcus fagisuga*) and one or more pathogenic fungi (genus *Neonectria*) that affect American Beech trees (Garnas et al. 2011, Cale et al. 2012). Infected trees experience reductions in radial growth, crown dieback and ultimately die (Cale et al. 2012). Large scale tree mortality and associated opening of the canopy alters forest composition and structure (Cale et al. 2012), favouring sunlight-loving species of more open habitats over shade-tolerant understory species such as Broad Beech Fern (Gould, pers. comm. 2013).

Climate Change

Canada is seeing rising temperatures, shifting precipitation patterns and increases in extreme weather events as a result of global climate change (Environment Canada

2012, 2013). While projections vary, particularly when based on different predictions of human behaviour and greenhouse gas emissions, most describe increases from 3 to 8 degrees Celsius by the end of the century (Ministry of Environment 2012, Gleeson et al. 2011, Varrin et al. 2007). Strong variability in weather patterns are of particular concern. Extreme weather events such as ice storms, heavy rains, droughts and wind storms are expected to occur more frequently and unpredictably (Gleeson et al. 2011).

In these climate change scenarios, species will need to adapt to changing temperatures and variability in weather events, or else be increasingly vulnerable. Climate is believed to limit the distribution of the Broad Beech Fern at the north of its range. While warmer average temperatures could extend the potential range of the species, existing fragmentation of habitat may prevent its northward expansion. Changes in rainfall patterns, such as increases in frequency of drought, could affect the availability of suitable conditions for gametophyte generation and the ability of the species to reproduce sexually.

Climate change could influence the impacts of invasive species on Broad Beech Fern habitat. Insect pests, for example, can be highly sensitive to temperature. According to Dukes et al. (2008) insects increase consumption, development and movement during warmer temperatures. Climate change has influenced the population dynamics of insects that have traditionally been controlled by cold winters (Dukes et al. 2008). For example, various species of bark beetle in British Columbia are no longer being controlled by cold snaps (Dukes et al. 2008), and the Hickory Bark Beetle in Ontario is having devastating impacts on trees that are weakened due to periods of drought (Kerr 2007, OMNR 2009).

Unsustainable Use

Broad Beech Fern is a frequently cultivated species, but collecting from the wild for horticultural purposes has not been documented in Ontario (Oldham 2004). Broad Beech Fern may occasionally be collected for native plant gardens or bouquets, as fern leaves are often considered attractive and decorative. No traditional use of Broad Beech Fern by aboriginal peoples of Ontario was found in the literature or interviews with First Nations contacts (Porchuk pers. comm. 2013).

4.0 MANAGEMENT

4.1 Goal and Objectives

Goal: The management goal is to maintain or enhance self-sustaining populations of Broad Beech Fern within its current range in Ontario.

Table 3: Management objectives

No.	Management objective
1	Identify, protect and manage known populations of Broad Beech Fern and habitat in Ontario.
2	Address key knowledge gaps relating to minimum viable population size, life cycle requirements, habitat requirements, and prioritization of threats.
3	Support and implement landscape- and ecosystem-based planning and recovery initiatives to increase the amount of available habitat for Broad Beech Fern. Enhance habitat connectivity for dispersal and population expansion.
4	Promote awareness and stewardship of Broad Beech Fern with First Nations and with stakeholders such as land managers, private landowners, municipalities and others
5	Reassess conservation status of Broad Beech Fern in Ontario.

4.2 Management Actions Completed or Underway

Rondeau Provincial Park manages deer populations because of negative deer browsing impacts on vegetation and forest regeneration. Species found palatable by deer were in decline and those not found palatable were becoming more abundant (OMNR 1991). Deer herd reductions were recommended for the Rondeau Provincial Park in 1991 (OMNR 1991) and have been undertaken at Rondeau Provincial Park regularly since 1993 (Gould, pers. Comm. 2013). According to Gould (pers. comm. 2013), understory growth and the abundance and distribution of many woodland species at risk has increased since deer herd reductions began (Gould, pers. comm. 2013). Gould (pers. comm. 2013) notes that deer populations in Rondeau can quickly reach overabundant densities and related impacts to species at risk habitat could return without population control.

Broad Beech Fern is a nested conservation target of Conservation Action Plans (CAPs) for the Short Hills (Jalava et al. 2012), Hamilton-Burlington 7E-3 (Jalava et al. 2010b), Ausable River-Kettle Point to Pinery (Jalava et al. 2010a), Rondeau-Erie Coast (Jalava et al. 2013) and Essex Forests and Wetlands (EFW NACP/CAP Team 2009) Carolinian Canada biodiversity hotspots. Recommended habitat stewardship and restoration activities, as well as public outreach and education associated with these CAPs are expected to benefit Broad Beech Fern populations in these areas.

Best management practices (BMPs) have been developed for Broad Beech Fern found on crown land in Ontario in the *Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales*. The guide was published by the Ontario Ministry of Natural Resources for use by —forest managers when planning and implementing operations involving harvest, renewal, tending, or the construction and use of roads, and landings on crown land in Ontario." The BMPs focus on identifying and protecting patches of Broad Beech Fern by maintaining high canopy cover and minimizing disturbance of the forest floor (OMNR 2010).

A landowner-oriented BMP fact sheet for Broad Beech Fern has been prepared by Carolinian Canada Coalition (CCC) and is available on the CCC web site at www.caroliniancanada.ca.

4.3 Management Plan Approaches for Action

Table 4. Management plan approaches for action for the Broad Beech Fern in Ontario

Management Theme	Management Approach	Relative Priority	Threats or Knowledge Gaps Addressed	Relative Timeframe
1. Identify, protect and manage extant populations of Broad Beech Fern and habitat in Ontario.				
Protection, Inventory, Monitoring and Assessment	<p>1.1 Identify extant populations in Ontario. Inventory areas with suitable habitat having historical reports of Broad Beech Fern.</p> <p>Determine the size and number of extant sites, site quality, population health and population trends.</p> <p>Conduct regular monitoring of extant populations.</p>	Critical	<ul style="list-style-type: none"> Habitat loss and degradation Invasive species Understanding current distribution, population size and threats, and causes of extirpation at historical sites. 	short-term
Protection	1.2 Identify impacts of land-use and management practices, both on-site and in adjacent areas that may affect habitat and site hydrology.	Critical	<ul style="list-style-type: none"> Detailed threats to species viability. 	short-term
Management	1.3 Develop Best Management Practices (BMPs), including guidelines for appropriate forest and watershed management within the watersheds of extant populations.	Critical	<ul style="list-style-type: none"> Habitat loss Detailed habitat requirements. 	short-term
Communication, Stewardship, Education and Outreach	1.4 Provide recommendations and BMPs to municipalities, conservation authorities, appropriate government ministries (e.g., MNR, OMAFRA, MOE, DFO and DND), adjacent landowners, private land site stewards, First Nation council members and land managers.	critical	<ul style="list-style-type: none"> Widespread understanding of species needs. 	short-term

Management Plan for the Broad Beech Fern in Ontario

Management Theme	Management Approach	Relative Priority	Threats or Knowledge Gaps Addressed	Relative Timeframe
Inventory, Monitoring and Assessment	1.5 Develop and apply monitoring protocol in association with monitoring other priority species of the overall Carolinian Woodlands Recovery Strategy.	necessary	<ul style="list-style-type: none"> Habitat loss 	ongoing
2. Address key knowledge gaps relating to minimum viable population size, life cycle requirements, habitat requirements, and prioritization of threats.				
Research	2.1 Support research to determine minimum viable population size requirements.	critical	<ul style="list-style-type: none"> Minimum viable population size in Ontario. 	short-term
Research	2.2 Evaluate and quantify the effects of varying levels of canopy removal on Broad Beech Fern.	necessary	<ul style="list-style-type: none"> Habitat loss, disease Invasive species Understanding how changes in canopy cover impact the species. 	short-term
Research	2.3 Support research to better understand the biology of the species (e.g., spore productivity, reproductive success and dispersal mechanisms) and habitat requirements for successful reproduction and dispersal.	beneficial	<ul style="list-style-type: none"> Reproductive biology, habitat requirements for reproductive success, dispersal requirements. 	long-term
Research	2.4 Investigate whether hybridization between Broad Beech Fern and Northern Beech Fern has occurred in Ontario.	beneficial	<ul style="list-style-type: none"> Better understanding of hybridization potential. Possible introgression with Northern Beech Fern. 	long-term
Research	2.5 Support research to understand the cultivation and establishment requirements in case they must be used to keep the species viable in Ontario.	beneficial	<ul style="list-style-type: none"> Better understanding of cultivation and establishment requirements. Populations fall below viable levels (due to various threats). 	long-term
3. Support and implement landscape- and ecosystem-based planning and recovery initiatives to increase the amount of available habitat for Broad Beech Fern, and enhance habitat connectivity for dispersal and population expansion.				

Management Plan for the Broad Beech Fern in Ontario

Management Theme	Management Approach	Relative Priority	Threats or Knowledge Gaps Addressed	Relative Timeframe
Management, Outreach, Communications	3.1 Support initiatives that protect, restore and rehabilitate natural landscape connectivity in areas where Broad Beech Fern is found (e.g., municipal natural heritage system plans, Carolinian Canada Coalition conservation action plans, conservation authority watersheds plans).	necessary	<ul style="list-style-type: none"> Habitat loss Habitat degradation 	short-term, ongoing
4. Promote awareness and stewardship of Broad Beech Fern with First Nations and with stakeholders such as land managers, private landowners, municipalities and others				
Education and Outreach, Communications	4.1 Develop and distribute Best Management Practices fact sheets and other information materials to inform land managers and land owners about the significance and biological needs of Broad Beech Fern.	necessary	<ul style="list-style-type: none"> All threats 	ongoing
5. Reassess conservation status of Broad Beech Fern in Ontario.				
Research	4.1 Encourage COSEWIC and COSSARO to reassess the conservation status of Broad Beech Fern in Ontario due to the apparent loss of a large proportion of occurrences.	necessary	<ul style="list-style-type: none"> All threats 	ongoing

GLOSSARY

Blade: The section of the fern frond that carries the leaflets.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): The committee responsible for assessing and classifying species at risk in Canada.

Committee on the Status of Species at Risk in Ontario (COSSARO): The committee established under section 3 of the *Endangered Species Act, 2007* that is responsible for assessing and classifying species at risk in Ontario.

Conservation status rank: A rank assigned to a species or ecological community that primarily conveys the degree of rarity of the species or community at the global (G), national (N) or subnational (S) level. These ranks, termed G-rank, N-rank and S-rank, are not legal designations. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by the letter G, N or S reflecting the appropriate geographic scale of the assessment. The numbers mean the following:

- 1 = critically imperilled
- 2 = imperilled
- 3 = vulnerable
- 4 = apparently secure
- 5 = secure

Ecozone: Describes an ecological area with a distinct combination of geologic, landform, soil, vegetation, climatic, water and human factors. Canada is divided into 15 terrestrial ecozones. (Parks Canada 2012)

Element Occurrence (EO): An element occurrence (EO) is an area of land and/or water in which an element (a unit of natural biological diversity) is or was present. These are defined and stored by the Natural Heritage Information Centre (NHIC). With immobile plants, a distance of 1 km is often used to separate occurrences.

- A - Excellent predicted viability
- B - Good predicted viability
- C - Fair predicted viability
- D - Probably not viable
- E - Verified extant
- F - Failed to find
- H - Historical
- X - Extirpated

Endangered Species Act, 2007 (ESA): The provincial legislation that provides protection to species at risk in Ontario.

Frond: The whole fern leaf that rises from the roots of the fern. Includes the both the blade and stipe.

Gametophyte: Growing from a spore, a gametophyte is a sexual generation of the fern that produces gametes, sex cells that will fuse upon fertilization (Mehltreter et al. 2010).

Phenotypic plasticity: The ability of a species to change its traits or characteristics to adapt to its environment.

Pinnae: Sections of leaflets that extend from the rachis.

Pinnules: Subleaflets that extend from the pinnae.

Pinnate-pinnatifid: Describes the fact that the lobes on the pinnule are not discrete, and remain sufficiently connected to each other so not to create separate leaflets.

Rachis (midrib): The central rib or stem of the fern blade.

Selection cutting: A silviculture practice of harvesting trees in order to move a forest stand toward an uneven-aged stand (OMNR 2011).

Selective logging: The practice of removing one or two trees from a forest stand while leaving the rest intact. Selective logging is a form of timber harvest and is considered an alternative to clear cutting.

Silviculture: An approach to forest management that uses a variety of methods to grow healthy trees in healthy forest stands and landscapes. The Ministry of Natural Resources (2011) recognizes three different methods (silvicultural systems) of harvesting and managing forests: the clear cut system, the shelterwood system, and the selection system (or selection cutting).

Species at Risk Act (SARA): The federal legislation that provides protection to species at risk in Canada. This act establishes Schedule 1 as the legal list of wildlife species at risk to which the SARA provisions apply. Schedules 2 and 3 contain lists of species that at the time the Act came into force needed to be reassessed. After species on Schedule 2 and 3 are reassessed and found to be at risk, they undergo the SARA listing process to be included in Schedule 1.

Species at Risk in Ontario (SARO) List: The regulation made under section 7 of the *Endangered Species Act, 2007* that provides the official status classification of species at risk in Ontario. This list was first published in 2004 as a policy and became a regulation in 2008.

Stipe (stalk): The section of the fern frond below the leaflets.

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APPENDIX A: Summary of Broad Beech Fern occurrences in Ontario

Element Occurrence (EO) Rank refers to Natural Heritage Information Centre (NHIC) ranks based on predicted viability of the occurrence.

EO Rank	
A	Excellent
B	Good
C	Fair
D	Probably not viable
E	Verified extant
F	Failed to find
H	Historic
X	Extirpated
*	status assigned as —H by NHIC (2013) requires update to “E”
**	status assigned as “E” by NHIC (2013) requires update to “H”
***	An EO candidate that has not yet been recorded as an EO by the NHIC.

Some ranks need to be updated to reflect current population status.

Upper Tier Municipality (# of extant EOs)	# of EOs (EO Ranks, Most Recent Observations)	Comments
Brant	1(E-2004), 3(H-1977), 1(X-1968,F-2002)	The most recent observation in Brant occurred at a conservation area in 2004, at which time 40 to 50 individual frond were extant. Three historical EOs are recorded, one of which is listed as extirpated and one of which has been intentionally surveyed in recent years (with no success).
Bruce (1)	1(E-1993)	Lion's Head Provincial Nature Reserve, no abundance information. Not found by J. Jalava (pers. obs.) during brief targeted search in mid-2000s.
Chatham-Kent	1(H-1986), 1(NR-1986), 1(BC-2003), 1(E-2004), 1*** (E-2004)	The most recent observation at Rondeau Provincial Park described as “several dozen plants” along trail. A conversation with park staff suggested that part of the Park's population is not accessible to the public (Slavik, pers. comm. 2013). Sighting on private property in 2004 (NHIC 2013).
Elgin (2)	2(E-1993,2004), 9(H-1986)	Most populations on private land. One occurrence on conservation authority lands (not documented since 1978). John E. Pearce Provincial Park cited as having 19+ stems in 2004. Not found at three historical sites during targeted searches by OMNR in 2004.
Essex (1)	1(E-2004), 1(H-1901)	Most recent observation (2004) in Essex occurred on an Essex Region Conservation Authority property. The population was described as small (four plants) and looked “browsed by insects”. There were no plants found in 2004 for the second EO.

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Upper Tier Municipality (# of extant EOs)	# of EOs (EO Ranks, Most Recent Observations)	Comments
Frontenac (2)	1(A-2005), 1(B-2005), 3(H-1975)	Over 200 fronds were counted in 2005 at Frontenac Provincial. There are two locations in the Park, one of which appeared browsed by deer in 2001 (Brdar, pers. comm. 2013).
Haldimand-Norfolk (5)	1(B-2002), 1(BC-2002), 2(CD-2004), 1(E*-2002), 8(H-1986), 1(F-2004), 1*** (E-2010)	There are 14 EOs listed for Haldimand-Norfolk. Five are extant occurrences, three on Long Point Region Conservation Authority lands and two on private lands. One EO represents a failure to find Broad Beech Fern. Eight EOs are historic, four of which have been intentionally surveyed with the species not being found. One EO candidate in the area has been described as a healthy population with 65 stems (NHIC 2013).
Halton (0)	1(H*-1990)	
Hamilton (3)	1(C-2003), 2(H-1979),	The one extant occurrence in Hamilton is located on private land and is cited as a small population (50-60 fronds in 2003, several of which were fertile) that has steadily been increasing. There are historic populations recorded at the Royal Botanical Gardens. While the exact causes of decline are unknown, two populations were adjacent to sports fields and another was near a high-use trail. Staff also point to overall changes in climate, specifically the "increasing frequency and duration of hot, dry conditions" (Harrison, pers. comm. 2013).
Lambton (1)	1(E-1993)	Kettle and Stony Point First Nation lands (Ipperwash Beach), cited as "rare and local". Not found in targeted survey in 2004.
Leeds and Grenville (0)	2(H-1982)	Occurrences presumed to be on private land.
Middlesex (0)	3(H-1974) 1(X-1*) (E-2009)	One occurrence on Ausable Bayfield Conservation Authority lands (2009). According to Jean (pers. comm. 2013), the population "is located away from trails and is protected from human disturbance by steeply sloping topography". Not found at one historical site during a targeted search in 2004.
Muskoka (1)	1(E-late 1990s)	Wahta First Nation lands.
Niagara (2)	1(C-2004), 1(E-2004), 3(H-1978), 3(X-1911) 1*** (E-2009)	Several EO occurs on private properties in the Fonthill region, with populations exceeding 50+ fronds. Three EOs are historic, and three are considered extirpated because the areas are now heavily populated and/or used for orchard/vineyard.
Toronto (0)	1(H-1890)	Historic record. Population is probably extirpated given the location is in a highly developed metropolis.

(NHIC 2013, Smith and Rothfels 2004)